Classifying Small for Gestational Age Infants with Consideration for Multiple Variables

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Abstract

According to the theory of prenatal programming, small for gestational age (SGA) infants are at an increased risk for adverse health conditions later in life, including diabetes, obesity, and cardiovascular disease. Proper identification of these at-risk infants is necessary in order to monitor, prevent, and manage these risk conditions throughout the lifespan. Infant birth weight is categorized as SGA (less than the 10^{th} percentile), appropriate for gestational age (AGA, 10^{th} to 90^{th} percentile), and large for gestational age (LGA, above the 90^{th} percentile) on standard growth charts. However, growth charts differ in the factors that are considered for classification. Some charts use weight alone, while others consider such factors as gender and gestational age.. The purpose of this study is to determine if the method of reporting infant birth weight affects the rate of identification of SGA infants. This study is a retrospective, descriptive study using data that were collected from participants in a randomized trial entitled "Exercise Intervention to Reduce Recurrent Preeclampsia" (R01 NR05275). The study sample was composed of 120 subjects. Mean infant GA at birth was 38 weeks with a standard deviation (SD) of 2.3 weeks. Mean infant weight was 3,391.5 grams, with an SD of 612.8 grams. Fifty-three percent of infants were male while forty-seven percent were female. Infants were classified using three different methods: weight expressed in grams, weight expressed in grams with consideration for GA, and weight expressed in grams with consideration for GA and gender. Rates of SGA, AGA, and LGA infant identification were compared and found to differ significantly across the three methods, confirmed by a chi-square analysis ($F_{4,90}$=26.49), with a p-value of less than 0.0001.. The importance of correct classification of SGA infants is made evident in that some infants may not be identified as at risk when classified by weight alone, leaving them at increased risk for chronic disease later in life, but with no increase in the amount of preventative care they receive.

Background

David J. Barker developed the theory of prenatal programming in 1986, proposing that the long-term health status of an infant is largely determined in the womb (Hays, 2011). The term programming was defined by Barker as "the process whereby a stimulus or insult at a sensitive or critical period of development has long-term effects" (p. 22). In the case of prenatal programming, this means that the beneficial or detrimental effects of low birth weight can have an effect on health status throughout the lifespan. Multiple diseases including obesity, diabetes, hypertension, stroke, osteoporosis, premature aging and ischemic cardiovascular disease have been associated with low birth weight and resulting catch-up growth in infants (Lau, Rogers, Desai & Ross, 2011; Weaver, 2012; "The barker theory," 2013).

Currently there is a shift of focus in healthcare from acute care to preventative care as a means to effectively manage and prevent adverse health events in a more cost-effective manner. The Patient Protection and Affordable Care Act, the impetus for healthcare reform in the United States, will be increasing the amount of preventative care that will be covered under insurance ("Preventative services covered," 2010). This legislation exemplifies the growing trend towards a focus on primary and secondary interventions aimed at preventing disease, rather than tertiary preventions aimed at managing and treating the complications of chronic disease. The need for a standardized method of identifying SGA infants becomes apparent when SGA status is recognized as a significant risk factor for chronic diseases such as hypertension and diabetes, which when not properly managed with preventative care, can lead to more serious medical conditions such as cerebral vascular accidents and myocardial infarctions.

At birth, infant weight is compared against reference growth charts in order to determine if the newborn's weight is abnormal. Birth weight can be categorized as SGA (less than the 10th

percentile), appropriate for gestational age (AGA, 10^{th} to 90^{th} percentile), and large for gestational age (LGA, above the 90^{th} percentile) on standard growth charts. Unfortunately, there exists a multitude of different reference charts currently in use, all with considerable variation. Goldenberg et al. reviewed standards for the diagnosis of intrauterine growth restricted infants across the United States and found that 10^{th} percentile reference values across 38 different studies varied by almost 500 grams at term (Bakketeig, 1998). With no standardization for the 10^{th} percentile reference value, SGA infant identification is variable across organizations. This results in the misclassification of some SGA newborns as AGA.

The correlation between low birth weight and poor health outcomes was discovered in the early nineteenth century, during a time when high rates of infant mortality were a major focus of research for medical professionals (Weaver, 2012). Weights, lengths, and the growth patterns of infants over time were recorded and examined. However, controversy existed over the best standard to measure infant weight against. Some researchers preferred the widely accepted rule of thumb that infants should double their weight by six months, and triple it by one year of age (Weaver, 2011). Growth charts that were developed at this time gave little consideration to the influence of gestational age, gender, or race on birth weight. The "mean values of unspecified numbers of infants from undetermined populations were used in the construction of growth charts", leaving charts that were ungeneralizable and often inaccurate due to the nature of the sample population (p. 7).

Some older classification systems take weight alone into consideration to identify infants who are low birth weight. Categories used include very low (less than 1,500 grams), low (less than 2,500 grams), or normal (2,500 grams or more) (Reichman, 2005). Large birth weight infants are those who weigh over 4,000 grams at birth, a condition known as macrosomia

(Davidson, London & Ladewig, 2007, p. 929). However, over time it has became apparent to clinicians that infants can meet weight requirements but still be immature and at risk for health complications. Conversely, small infants can still be functionally mature. Much like the growth charts used in the nineteenth century, these classifications fail to consider the effects gestational age, gender, and race can have on birth weight and infant growth.

The bulk of weight gain in-utero occurs in the third trimester of pregnancy, with subcutaneous fat beginning to be laid down at approximately 32 weeks gestation (p. 254). From that point on, the fetus is gaining weight at an increased rate. Infants who are born before the full-term designation of 38 weeks will have fewer fat deposits and therefore naturally weigh less than those who are born at or after term, highlighting the importance of gestational age in classifying infant weight status. In general male infants have a tendency to weigh more than females. Research has shown that this holds true across all gestational ages and racial/ethnic groups (Alexander, Kogan & Himes, 1999, p. 229).

The impact that race has on infant birth weight is less clear, but has been heavily researched. A study using data on single live births recorded in the 1994-1996 U.S. Natality Files found that non-Hispanic white infants were fairly comparable in birth weight while African American infants were markedly smaller (p. 228). “Compared with White and Latino women, African American women are reportedly at highest risk for delivering low birth weight infants and delivering prematurely” (Hamilton, Martin &Ventura, 2006). It is still unclear what physiological or social mechanisms cause this trend, however it points out the importance of race in classifying infant birth weight status. If an African American infant’s birth weight is compared against standards developed using non-Hispanic white infants, they may be incorrectly identified as SGA.

Growth charts currently in use have been developed using multiple different methods and variable population samples (Bakketeig, 1998; Weaver, 2011, p. 1). Two commonly used reference charts are those developed by the Center for Disease Control (CDC) and the World Health Organization (WHO). These charts consider birth weight and weight gain in infancy, thus the method of feeding is an important consideration. The CDC reference chart used sample populations of mostly formula-fed infants, while the WHO growth charts have been developed using only breastfed infants living in ideal conditions (Beck, 2012). The WHO has claimed that its reference charts are "potentially universally applicable to all children worldwide" due to the number of different countries they have based their standards on, however the truth of this statement is questionable (Weaver, 2011, p. 4).

The problem lies in the differing growth patterns of breast-fed and formula-fed newborns, with breast-fed newborns gaining weight at a slower rate during the first six months of life. If a breast-fed infant fails to keep up with the standards established by the CDC growth charts, some mothers may be inclined, or even pressured, to stop breast-feeding their infants (Beck, 2012). However, the American Academy of Physicians recommends exclusive breastfeeding for the first six months of life as the preferred feeding method for all infants (Davidson, London & Ladewig, 2007, p. 897). It has been found that the slower growth trajectory of breastfeed babies, as compared to formula-fed infants, can actually be protective against disease later in life (Weaver, 2011, p. 7). Due to the immunological, psychosocial, and nutritional benefits associated with breast-feeding, it is important to encourage mothers to continue breastfeeding their infants.

Multiple variables can affect the birth weight of an infant, and all must be considered when looking to identify SGA infants. The current standards for classification are variable, which can result in confusion for mothers and possibly detrimental health effects on newborns later in life. The need for a standardized method of SGA identification is clear.

Purpose

The purpose of this study was to determine if the method used to classify infant birth weight affects the rate of identification of SGA infants. We hypothesized that the classification of birth weight that includes consideration for both gestational age (GA) and gender will result in a greater percentage of infants who are classified as SGA, as compared to those who are classified by birth weight alone.

Methods

The research design was an exploratory secondary, retrospective analysis using the descriptive method. De-identified data, including infant birth weight, gender, and race, were extracted from a randomized trial entitled "Exercise Intervention to Reduce Recurrent Preeclampsia" (R01 NR05275).

Three different methods were used to categorize the sample as SGA, AGA, or LGA. First, weight alone was used as a classification factor (Method One). SGA infants were defined as those weighing less than 2,500 grams at birth, while those above 4,000 grams were defined as LGA. Next, both weight and GA were considered, using a chart developed by Abbott Nutrition (Method Two) (Figure One) (2008). Lastly, weight, GA, and gender were all considered as contributing factors using reference charts created by Pediatrix Medical Group (Method Three) (Figure Two) (Olsen, Groveman, Lawson, Clark & Zemel, 2010).

Data were analyzed in two separate methods. First, the frequencies of infant weight status identification were considered within each method. As previously stated, SGA infants are those that fall below the 10^{th} percentile on a standardized growth chart, while LGA infants are those

Figure One: Standardized Growth Chart

with Consideration for Weight and GA

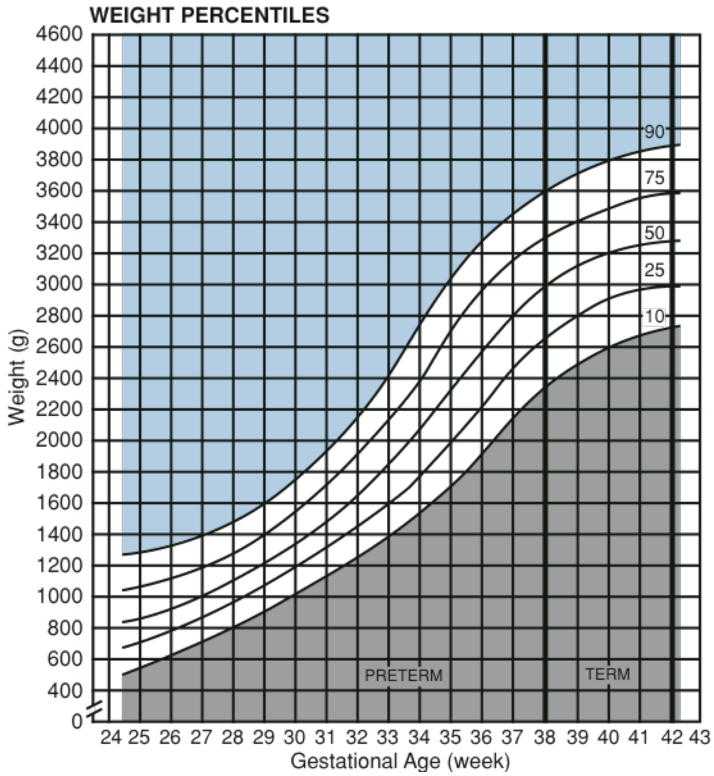
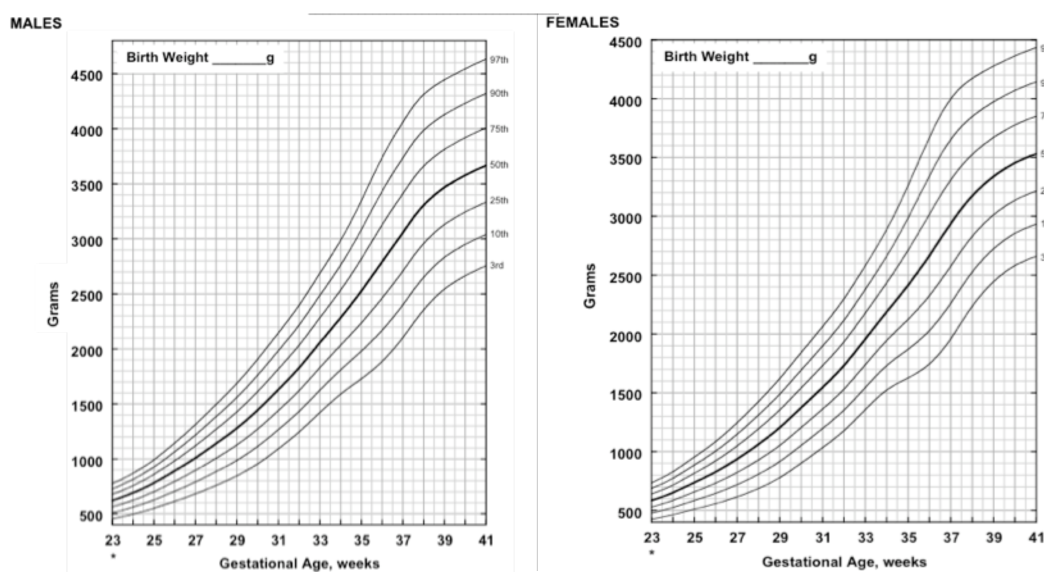


Figure Two: Standardized Growth Cart with

Consideration for Weight, GA, and Gender



that fall above the 90^{th} percentile. Theoretically, with a sample size of 100 infants, an accurate growth chart would then classify ten percent of the infants as SGA (10 infants), ten percent as LGA (10 infants), and eighty percent as AGA (80 infants). To determine the accuracy of the three methods used, percentages of birth weight classifications within each method were examined with consideration for differing sample sizes. Secondly, rates of SGA identification were analyzed across all three methods using a chi-square analysis to test for statistically significant differences.

Sample Population

Data from 120 participants were collected, with complete maternal data on 97 participants and complete infant data on 79 participants. Participants were women with a previous history of preeclampsia during labor. During the study, women participated in an exercise program to determine if physical activity would reduce the risk of recurrent preeclampsia.

Mean maternal age among the sample of women was 30 years with a standard deviation (SD) of 5.3 years. Mean GA of the infants was 38 weeks with an SD of 2.3 weeks. Mean infant weight was 3,391.5 grams, with an SD of 612.8 grams. Fifty-three percent of the infants were male and forty-seven percent were female.

Results

Infant data were manually analyzed and plotted against the growth charts. Sample size across the three classification methods varied. As more factors were considered in determining weight status, fewer subjects had complete data to report. Complete data on infant sex, weight, and GA were available for only 90 subjects. The data was complied into Table One.

Table One: Rates of Birth Weight Status Designation Using Three Different Methods of Classification

	Method One (n=96)	Method Two (n=95)	Method Three (n=90)
SGA	*7*	*1*	*5*
AGA	*80*	*61*	*74*
LGA	*9*	*33*	*11*

Percentages were then calculated for the number of infants put into each category across the three methods (Table Two). These percentages were compared to the theoretical number of infants that should have been identified based on the standard definitions of SGA infants and LGA infants as those below the 10th and above the 90th percentiles (Table Three).

Table Two: Birth Weight Status Percentages Across Three Classification Methods

	Method One (n=96)	Method Two (n=95)	Method Three (n=90)
SGA	*7.3%*	*1.1%*	*5.6%*
AGA	*83.3%*	*64.2%*	*82.2%*
LGA	*9.4%*	*34.7%*	*12.2%*

Table Three: Theoretical Birth Weight Status Percentages Based on Standard Definitions and Differing Sample Sizes

	Method One (n=96)	Method Two (n=95)	Method Three (n=90)
SGA	*9.6%*	*9.5%*	*9%*
AGA	*76.8%*	*76%*	*72%*
LGA	*9.6%*	*9.5%*	*9%*

Surprisingly, of all three methods, the least-specific Method One had the closest distribution to the ideal standard. When GA was incorporated into Method Two, the distribution changed drastically. Unexpectedly, the number of SGA infants went down, and the number of LGA infants increased dramatically. When gender was considered as a third factor in Method Three, the distribution came back into more normal ranges.

Secondly, a chi-square analysis was run to compare the rates of identification across all three methods (Preacher, 2001). A chi-square value of 26.489 (4, n=90) was computed, with a p-value of less than 0.0001, which indicated statistical significance.

Discussion

As a purely exploratory study, this study examined the idea that the method used to classify infant birth weight will cause significant differences in the rate of SGA infant identification. The chi-square analysis with a p-vale of less than 0.05 indicates statistically significant differences in the results across the three methods. We originally hypothesized that the method that accounted for birth weight, GA, and gender (Method Three) would result in an increased percentage of infants classified as SGA as compared to the method considering weight alone (Method One). Once analyzed, data showed that 7.3% of infants were classified as SGA in Method One, compared to only 5.6% using Method Three, thus disproving our hypothesis.

However, during the course of this project it became evident that an increased percentage of SGA infants identified does not necessarily indicate accuracy. It is more important to determine which of the three methods is the most accurate than which one provides the highest number of identified SGA infants. Further research on this topic would necessitate post-hoc analysis of the data to determine the most accurate method.

Another expected finding was to see distributions that more closely followed the ideal standard as methods of classification became more specific. However, Method One represented a distribution closest to the ideal standard based on its sample size. When GA was added as a factor for Method Two, rates of identification drastically changed. Only one SGA infant was identified, while an alarming 33 out of 95 infants were identified as LGA, a possible reflection on the current obesity epidemic in this country (Lau, Rogers, Desai & Ross, 2011; "Overweight and obesity," 2012). Distributions returned to more ideal rates when gender was included in Method Three, however this trend was not an expected finding. These results serve to only further prove how much SGA and LGA rates can differ between classification methods, and further highlight the need to develop a standardized, accurate method of classification based on evidence.

Furthermore, as this study has shown, the identification of LGA infants is becoming an equally important concern for healthcare providers. Large infants are at increased risk for childhood and adult obesity, which are known risk factors for a multitude of chronic diseases and health complications (Lau, Rogers, Desai & Ross, 2011). Parents often consider large infants to be very healthy and robust, viewing the excessive weight gain as a positive sign. It is necessary to change thought processes and begin identifying large infants as equally prone as small infants to developing health complications later in life.

Implications for Practice

Healthcare providers need to be aware of what methods are being used to determine infant weight status in their organization. Further research is needed to determine what method of classification is most accurate, and a standardized growth chart needs to be adopted nationwide so that the identification of SGA infants will be more consistent. After SGA infants are identified, healthcare providers need to be aware of the preventative services that will be needed for these infants as they begin to grow up.

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